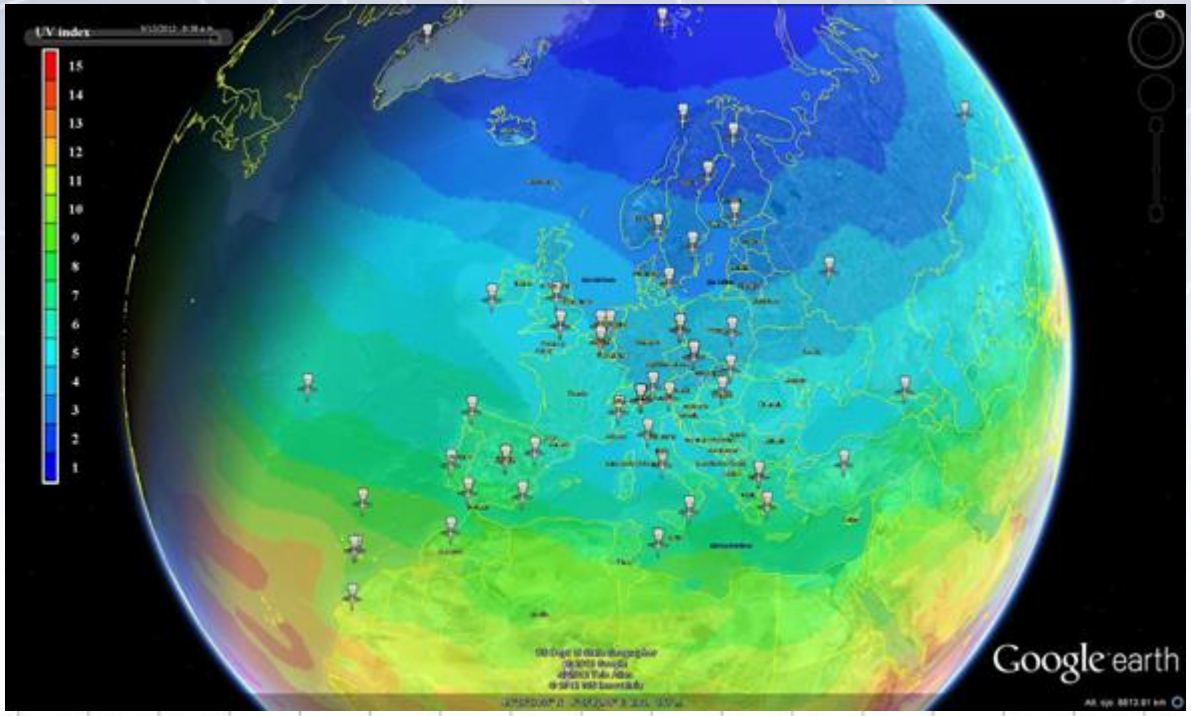
GOBIERNO DE ESPAÑA

MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

AEMet Agencia Estatal de Meteorología

# EUBREWNET
# RBCC-E calibrations



# REGIONAL BREWER CALIBRATION CENTER-EUROPE
# CEOS-ESA CALVAL campaigns instrumental findings

Alberto Redondas , Juan Jose Rodriguez

# Outline

- Brewer ozone Calibration
- Instrumental issues
  - Ozone cross section
  - Filter nonlinearity
  - Dead Time
  - Stray Light
- One parameter vs two parameter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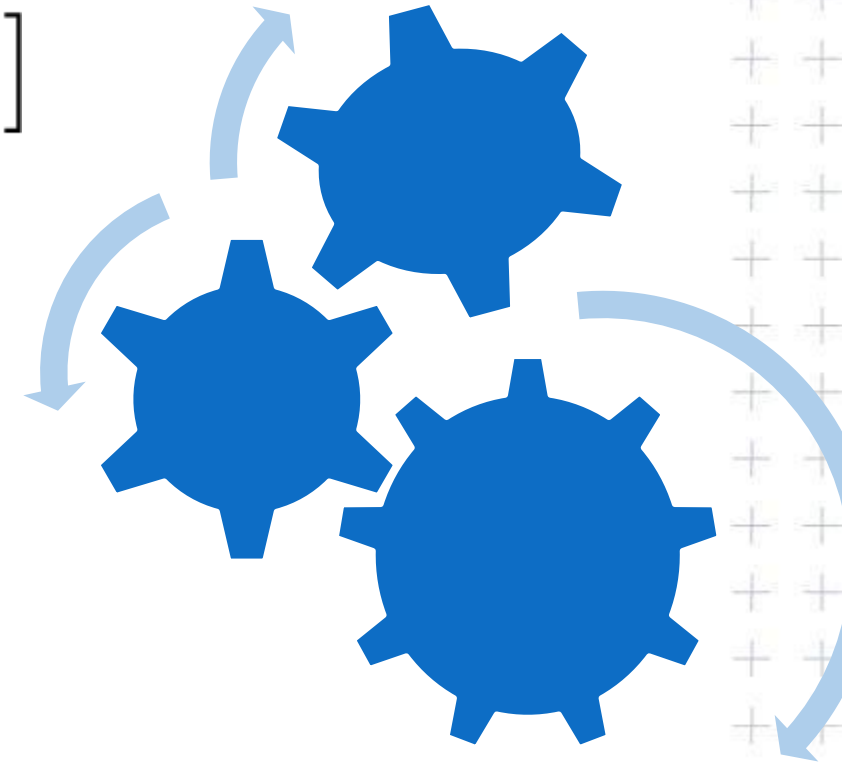
# Brewer Calibration

$$[O_3 = \frac{F - ETC}{\alpha\, m}]$$

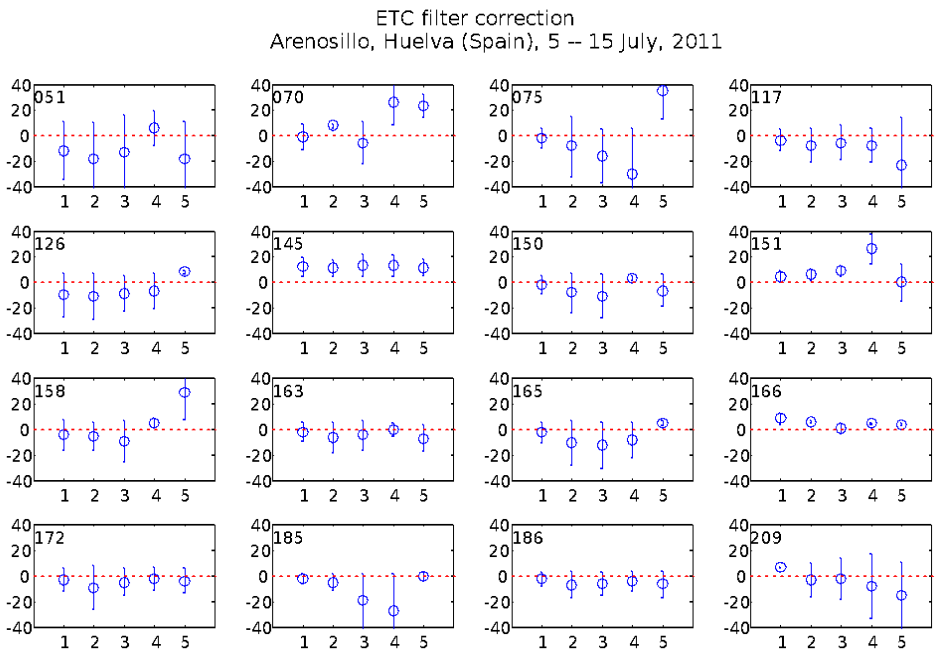
- 1: Instrumental Calibration (F)
- 2: Wavelength Calibration (α)
- 3: ETC transfer.



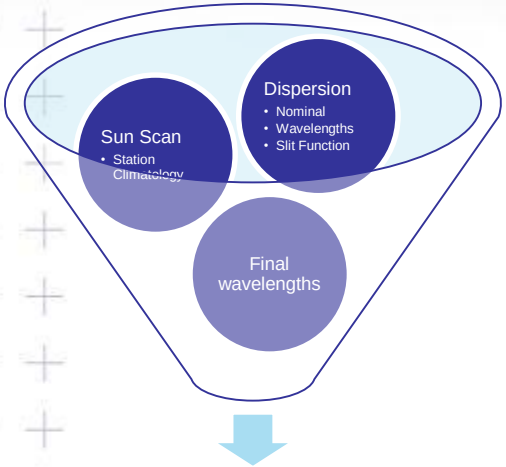
# Instrumental calibration

$$F = F(DeadTime, Filter, Temperature)$$

- 
- Characterization test determine /track the changes
- Test are well described on Brewer SOP



# Wavelength Calibration




1. Optimized wavelengths (Sun Scan)
2. Dispersion test, (discharge lamps)
3. Ozone Cross Sections (Bass & Paur -45 ).

$$\tilde{\alpha}(X,\mu) = \sum w_i \frac{\int \alpha(\lambda) * S(\lambda,\lambda') * F(\lambda,\lambda',X,\mu) d\lambda'}{\int S(\lambda,\lambda') * F(\lambda,\lambda',X,\mu) d\lambda'}$$

α(λ) = ozone cross section

Wi= ozone weighting coefficients

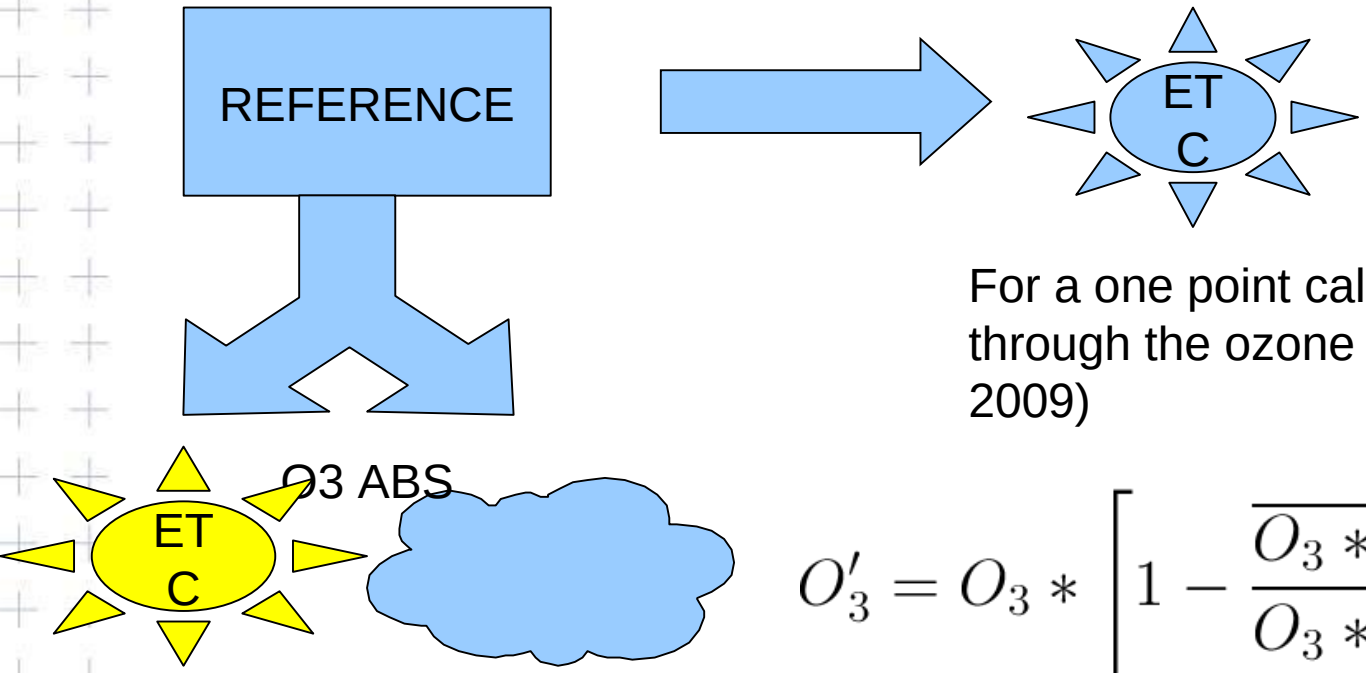
S = Slit Function, (ILS)

F = Sun Spectra , (X, nu)

Gröbner, J., Wardle, D. I., McElroy, C. T. y Kerr, J. B.: Investigation of the wavelength accuracy of Brewer spectrophotometers, APPLIED OPTICS, 37(36), 1998.

# ETC transfer

The reference instruments , the ETC are calibrated by Langley extrapolation
The network instrument  the ETC is obtained by comparison with the reference
Before year 2000, ozone absorption cross section and ETC were transferred from the reference



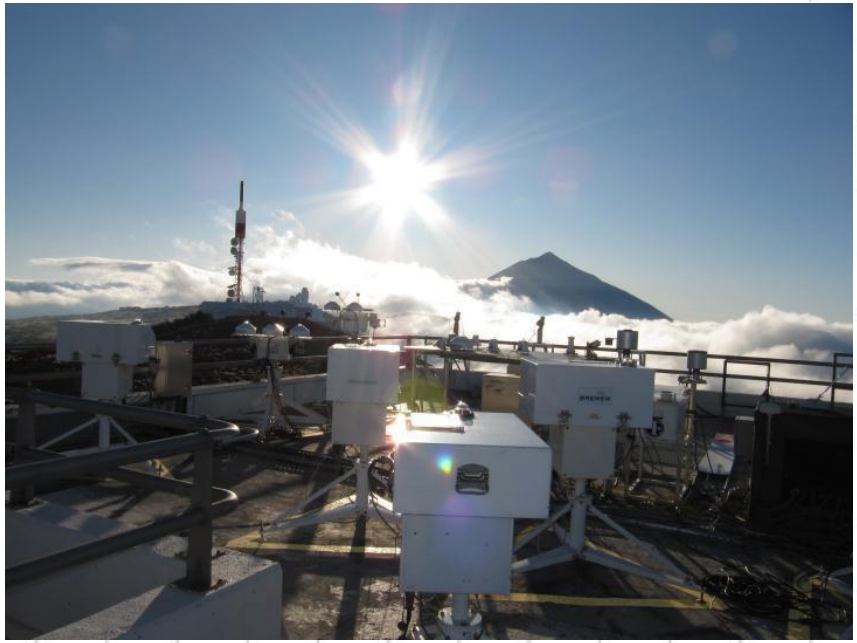

For a one point calibration there is a dependence through the ozone from a reference (Savastiouk 2009)

$$O_3' = O_3 * \left[ 1 - \frac{\overline{O_3 * \mu}}{O_3 * \mu} \left[ 1 - \frac{\alpha_{ref(dm)} / \alpha_{ref(bp)}}{\alpha_{inst(Dm)} / \alpha_{inst(bp)}} \right. \right.$$

There is no effect on ETC transfer with the change of ozone absorption coefficients with  a two point calibration.

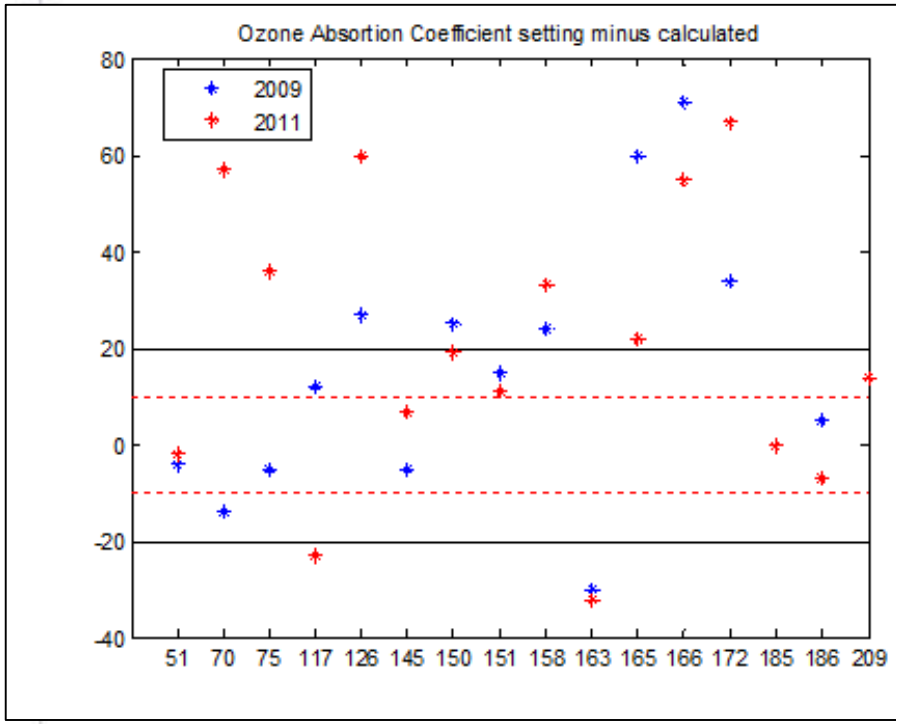
# Instrumental issues found at CEOS campaigns

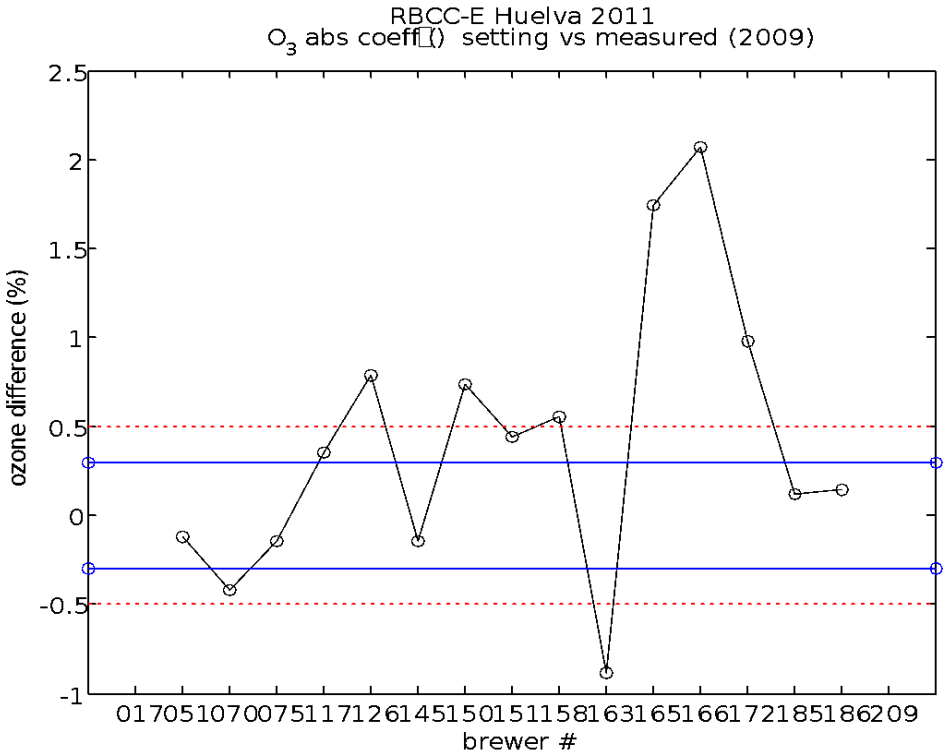
a. Ozone Absorption :Two point  vs. one point calibration
b. Stray Light
c. Dead Time
d. Filter Attenuation
e. Stray Light



# Ozone Absorption coefficient

About one third of the instruments the ozone absorption calculated are not agree with the calibration setting. They are using two parameters calculation

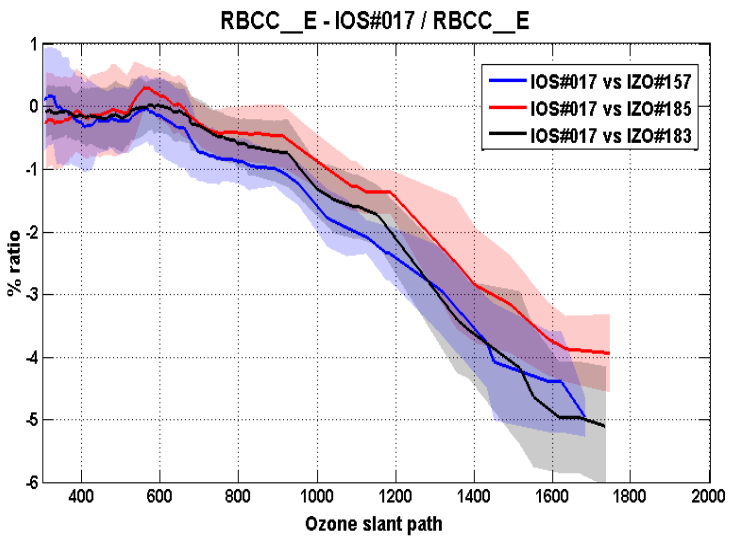


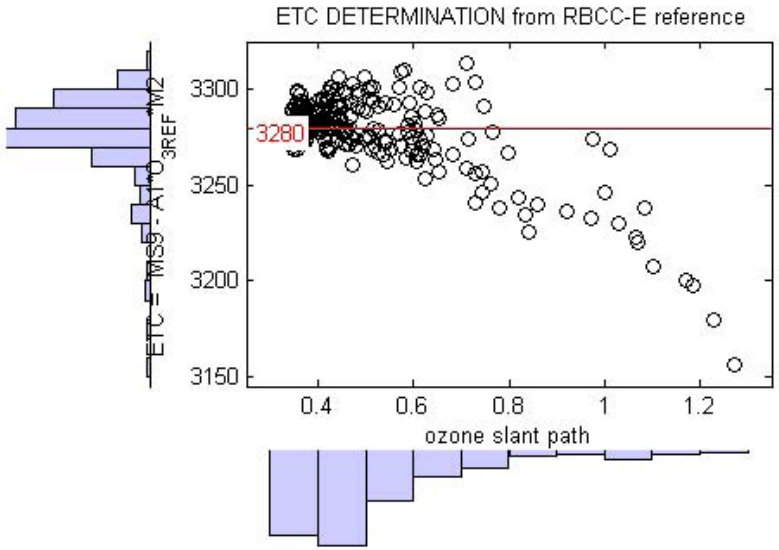



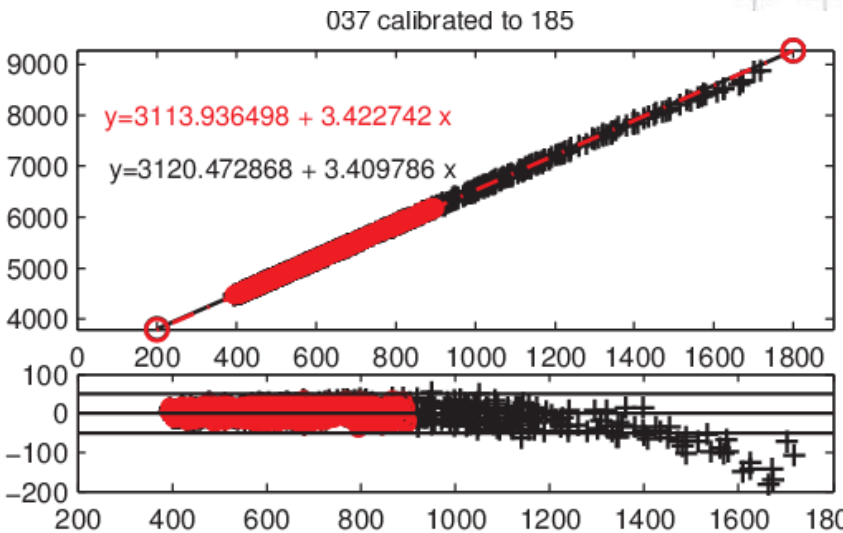
# Straylight

Reference instruments are affected by stray light

Limits the useful calibration range

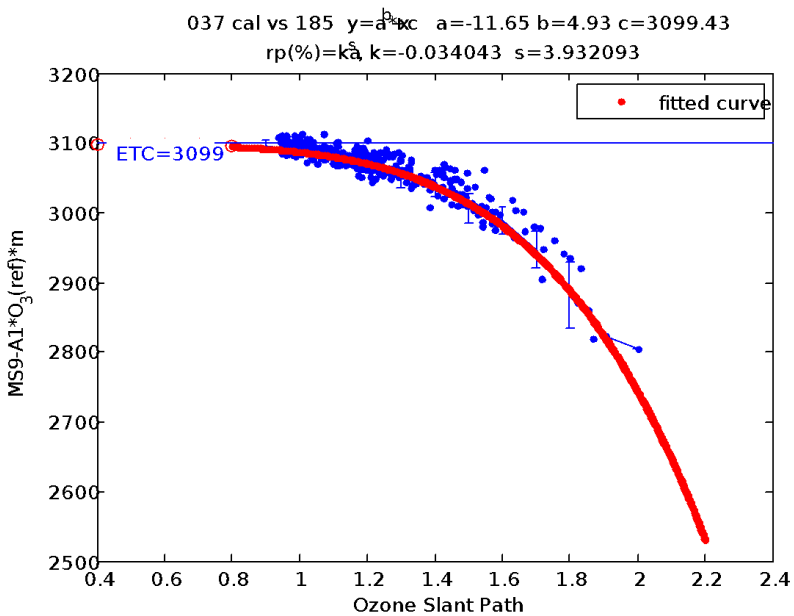


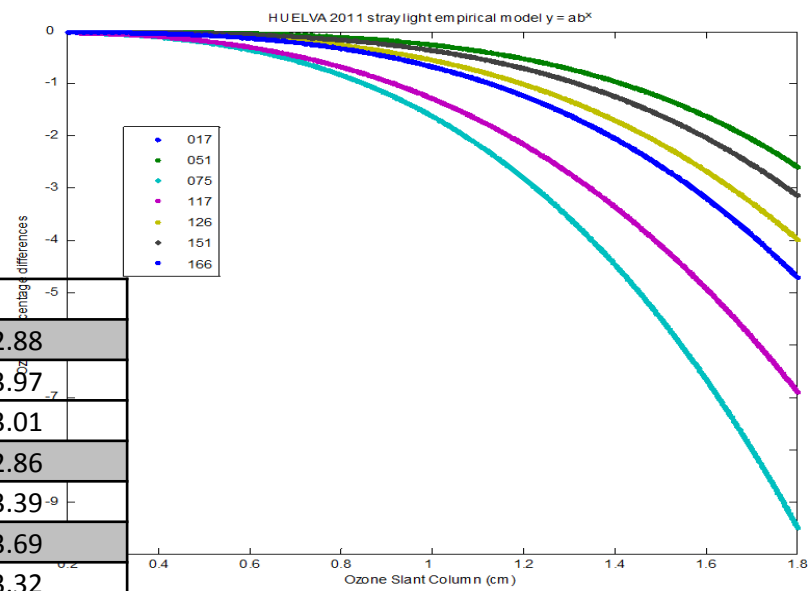



# Stray Light

- The empirical relation found at SAUNA with campaigns can be applied to ETC transfer $ETC = ETC0 + a(osc)^s$

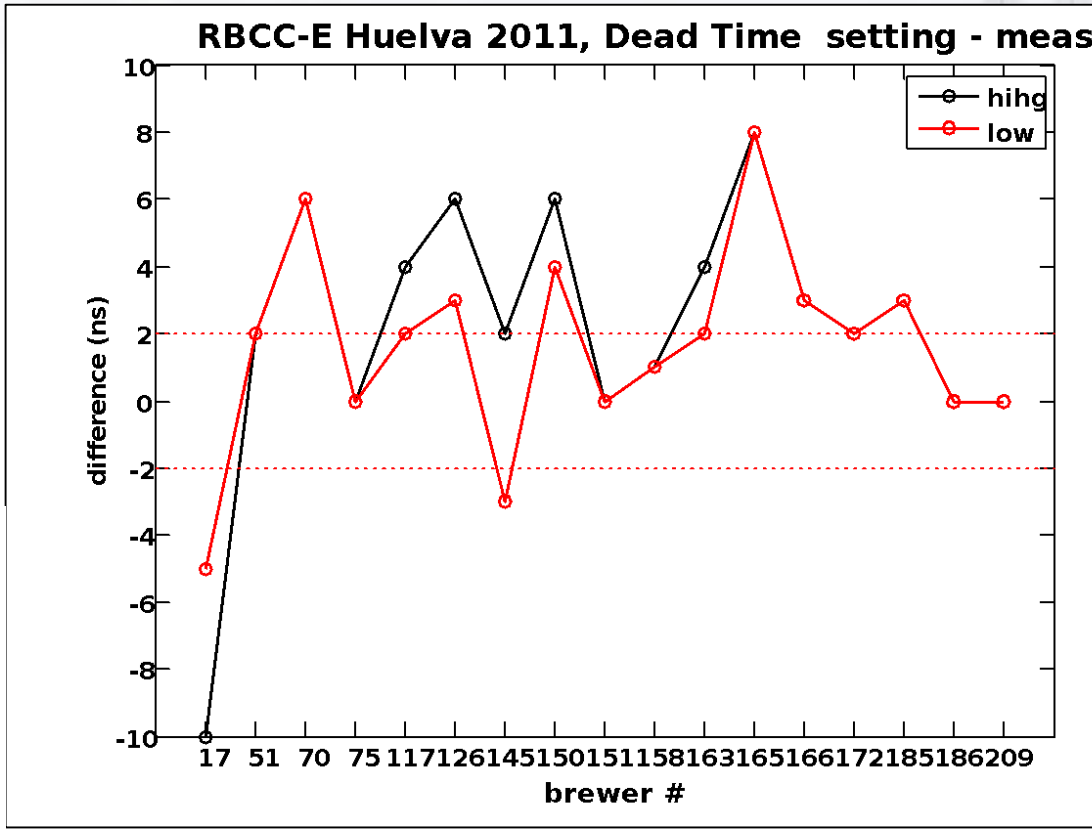


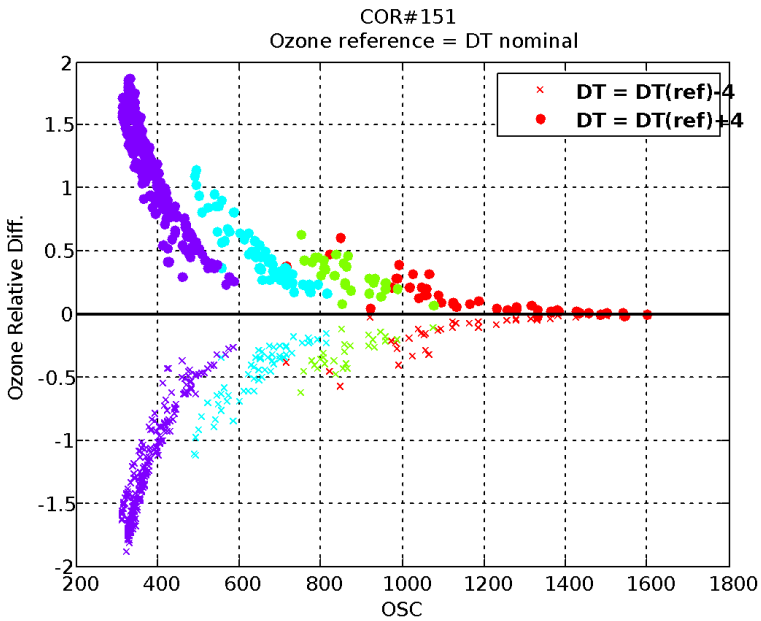

| Brewer | a | s |
|---|---|---|
| 17 | -1.09 | 2.88 |
| 51 | -0.25 | 3.97 |
| 75 | -1.62 | 3.01 |
| 117 | -1.28 | 2.86 |
| 126 | -0.54 | 3.39 |
| 151 | -0.36 | 3.69 |
| 166 | -0.67 | 3.32 |



# Instrumental issues
# DT

a. The SOP indicates a tolerance 2 ns.
b. Effect up to 3% in single Brewer
c. The setting on the instrument are not agree with the calculation
d. This also affects to some “reference” instruments like #157 and #017



# Filter attenuation:

Attenuation Filters are “neutral”

Nominal wavelengths and weights verify

$$\sum_{i=1}^{4} w_i = 0, \qquad \sum_{i=1}^{4} w_i \lambda_i = 0$$

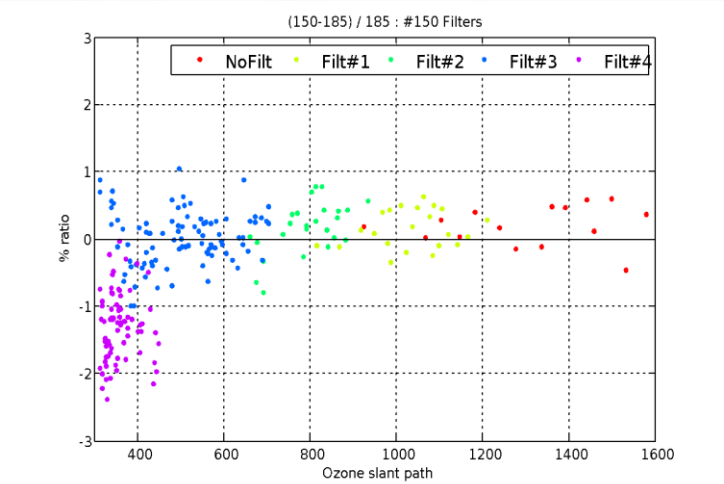
If the attenuation is linear with wavelength, do not affect the ozone calculation.

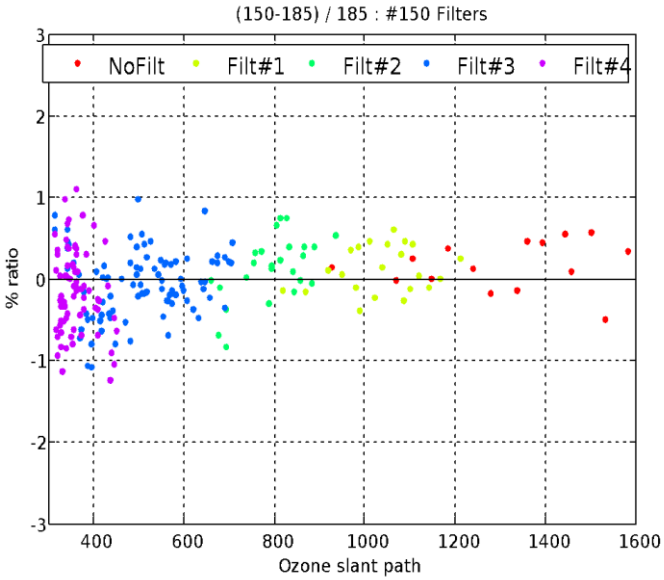
The filters can not be neutral and

$$\sum_{i=1}^{4} w_i \lambda_i \approx 0$$

The effect is a correction on ETC for the affected filter (j) , that can be calculated if you know the spectral attenuation AF

$$ETC\_C(j) = \sum_{i=1}^{4} w_i Af(\lambda_i, j)$$



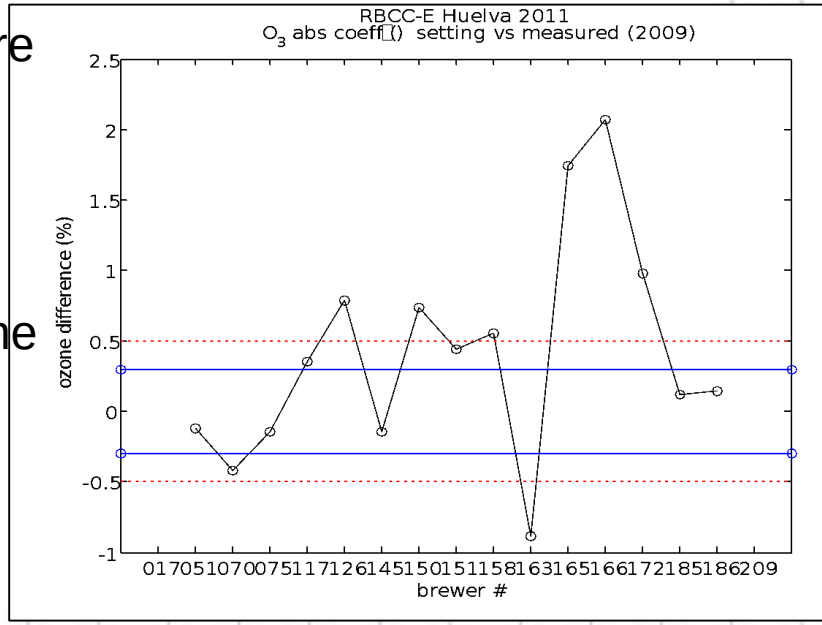
# Summary

| | 17 | 51 | 70 | 75 | 117 | 126 | 145 | 150 | 151 | 158 | 163 | 165 | 166 | 172 | 185 | 186 | 209 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABS | | | | X | | X | | X | | X | | X | X | X | | | | 40% |
| Filter | | | | X | | X | | X | | X | | X | X | X | (*) | | | 47% |
| DT | X | | X | | | X | | X | | | X | X | | | | | | 35% |

The instruments calibrated with two point calibration are the same that are affected by filter issues

**Coincidence ?**

No linearity of the filters are not take in to account on the current analysis software, the “synthetic” absorption coefficient can compensate this.



# Summary / Conclusions

- A significant number of brewers use two parameters calibration to compensate no linearity's.
- If a proper calibration is use both calibrations are agree, and this agreement can be use as indication of the quality of the instrument.
  - Class I: ETC (+/- 5 units .4% , $o_3$abs +/- 1 step 0.3% )
  - Class II : ETC (+/- 10 units .8%, $o_3$abs +/- 2 step .6%)

- About 2/3 of the instruments shows an agreement of +/-0.5% after two year calibration.

# Summary / Conclusions

- Filter Spectral configuration is desirable to include in the configuration file and on the brewer processing software.
- Two wavelengths calibration (ozone, and UV) are not desirable but is a compromise solution.
- Is not always possible to get/determine who parameter is casing the no-linearity in this case we two point calibration could be used.

- Ongoing work
  - DT from the sun
  - Instrumental constants from langley.

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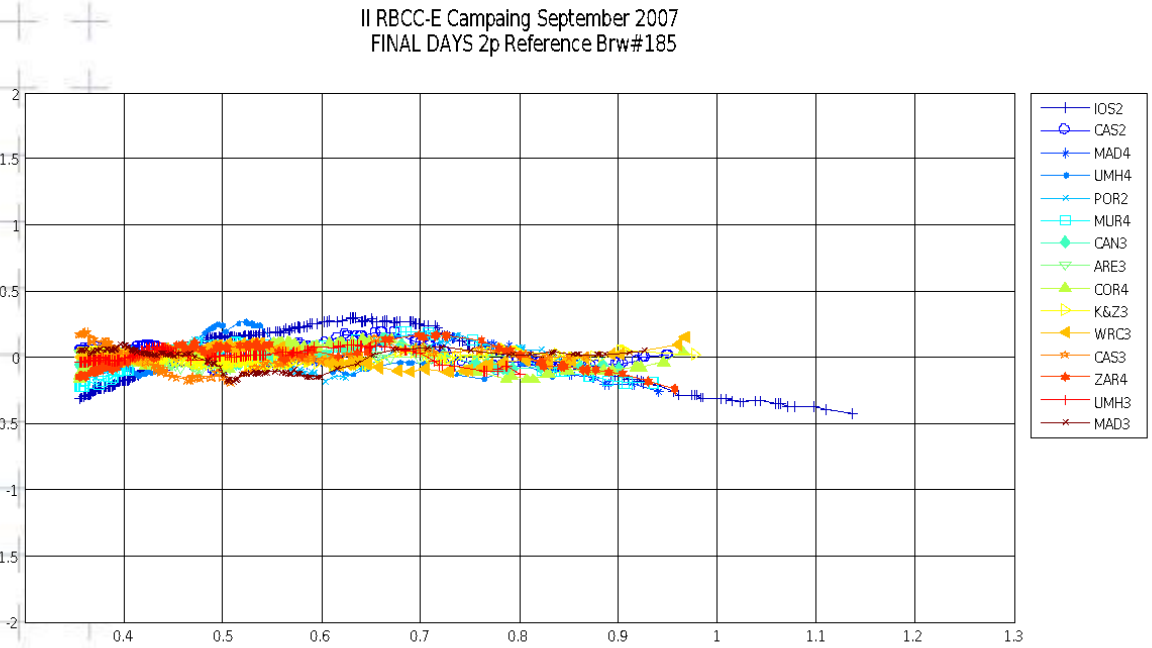
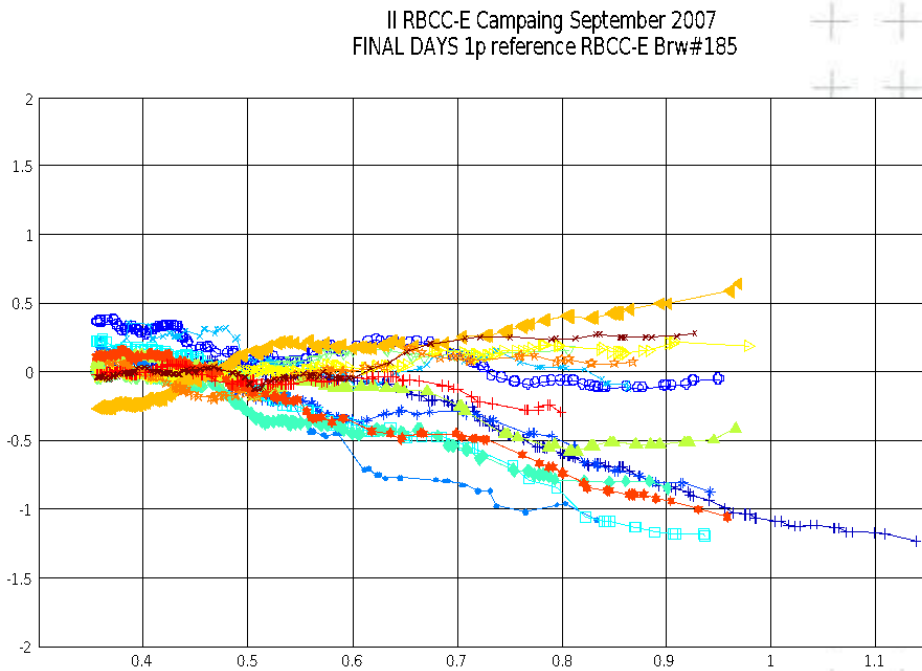

II RBCC-E Campaing September 2007
FINAL DAYS 2p Reference Brw#185
IOS2
CAS2
MAD4
UMH4
POR2
MUR4
CAN3
ARE3
COR4
K&Z3
WRC3
CAS3
ZAR4
UMH3
MAD3


II RBCC-E Campaing September 2007
FINAL DAYS 1p reference RBCC-E Brw#185

$$O_3 = \frac{\sum_{i=1}^{4} w_i \cdot \left[ Log(F_i) - Log(Fo_i) - AMF_{SCA} \cdot \frac{p}{p_0} \cdot \tau_{SCAi} \right]}{AMF_{O3} \cdot \sum_{i=1}^{4} w_i \cdot \tau_{O3i}}$$

weights $w_i$ : –1, +0.5, +2.2, and –1.7

Wavelengths : 310, 313, 317, and 320nm .

Fo : extraterrestrial count rates.

F : measured count rates

$P_0$ ,p : standard surface air pressure /average station air pressure

□$T_{SCAi}$ : molecular scattering optical depths for each wavelength I at po.

□$T_{O3i}$ : ozone absorption optical depths for each wavelength i.

$AMF_{SCA}$ : direct sun air mass factors for molecular scattering

$AMF_{O3}$ : direct sun air mass factors for ozone absorption respectively.

$$AMF_x = \sec\left\{ \arcsin\left[ \frac{R}{R + h_{EFFx}} \cdot \sin(SZA) \right] \right\}$$

R is the Earth's radius (6370km)

$h_{EFFx}$ is the effective layer height. ( It is set to $h_{EFFSCA}$=5km and $h_{EFFO3}$=22km.

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